REMARKS

The present response is intended to be fully responsive to all points of rejection raised by the Examiner in the Office Action dated January 25, 2006, and is believed to place the application in condition for allowance. Favorable reconsideration and allowance of the application is respectfully requested.

STATUS OF CLAIMS

All claims stand rejected or objected to. Claims 1 – 7 and 31 – 37 have been cancelled. Claims, 8, 10, 11, 20, 24, 38, and 46 have been amended. New claims 47 – 49 have been added, and restate claims 16, 20, and 24 respectively as "Beauregard" claims. No new matter has been added.

CLAIM OBJECTIONS

Claim 46 is objected to as being unclear as to what "a computer-readable medium" refers. Claim 46 is written as a "Beauregard" claim that relates to computer software that, by definition, a computer may read and execute. It is universally understood by persons of ordinary skill in the computer arts that such software can only be embodied on computer-readable media, and that such media may include, for example, magnetic storage. Applicants respectfully submit that "the methods and apparatus described herein may be readily implemented in computer hardware or software using conventional techniques," as mentioned on page 12, third paragraph, of the application, as well as claim 46 itself, being present in the application as filed, provide sufficient antecedent basis for referring to the computer-readable medium on which the software is necessarily stored. Applicants, therefore, respectfully request that the objection be withdrawn.

CLAIM REJECTIONS

35 U.S.C. § 102(b) Rejections

Claims 1 – 7, 12 – 23, 25 – 27, 31 – 37, 42 – 44, and 46 have been rejected under 35 U.S.C. §102(b), as being anticipated by Printezis, et al. (hereinafter "Printezis"). Applicants respectfully traverse this rejection in view of the remarks that follow.

Claims 1 – 7 are cancelled herewith without prejudice or disclaimer.

Claims 8 – 11 are amended herewith to depend directly or indirectly from claim 20.

Claim 12 recites, *inter alia*:

"...wherein either of steps a) and f) are performed for a given object ***only if*** the card to which the object belongs ***is not marked***, wherein any of steps a) – g) are performed upon said population of objects concurrently with the operation of a mutator..." (emphasis added).

*Thus, the recited feature limits tracing an object **only if** the object is on an unmarked card* during concurrent operation of a mutator.

Page 12 of the office action asserts that this feature is anticipated by Printezis at Fig. 1 and page 5, "A Concrete Example."

Applicants respectfully submit that Printezis does not anticipate the recited feature. *Neither Fig. 1 nor the text at page 5 give any indication that objects on marked pages are to be handled any differently than objects on unmarked cards* during the concurrent marking phase. The examiner's further point that "In Figure 1a pages 0, 1, 2 are unmarked/clean and have objects on these cards/pages" does not shed any light in this regard, as it does not teach that no tracing be performed on an object if it is on a marked card. Printezis therefore does not anticipate claim 12 under 35 U.S.C. § 102(b). Applicants respectfully request, therefore, that the rejection of claim 12 under 35 U.S.C. § 102(b) be withdrawn.

Claims and 13 – 15 depend directly or indirectly from independent claim 12, and are, *a fortiori*, deemed allowable. Applicants respectfully request, therefore, that the rejection of claims 13 – 15 under 35 U.S.C. § 102(b) be withdrawn.

Claim 16 recites, *inter alia*:

"...wherein prior to said unmarking step c) said card is marked ***only if*** there is at least one marked object ***already on said card***, wherein any of steps a) – g) are performed upon said population of objects concurrently with the operation of a mutator..." (emphasis added).

*Thus, the recited feature limits marking a card **only if** the card contains at least one marked object* during concurrent operation of a mutator.

Page 15 of the office action asserts that this feature is anticipated by Printezis at Fig. 1 and page 5, "A Concrete Example."

Applicants respectfully submit that Printezis does not anticipate the recited feature. *Neither Fig. 1 nor the text at page 5 give any indication that pages with marked objects are to be handled any differently than pages with unmarked objects* during the concurrent marking phase. Indeed, *Figure 1b clearly shows that page 3 has been marked despite the fact that its objects f and g are unmarked*. Printezis therefore does not anticipate claim 16 under 35 U.S.C. § 102(b). Applicants respectfully request, therefore, that the rejection of claim 16 under 35 U.S.C. § 102(b) be withdrawn.

Claims and 17 – 19 depend directly or indirectly from independent claim 12, and are, *a fortiori*, deemed allowable. Applicants respectfully request, therefore, that the rejection of claims 17 – 19 under 35 U.S.C. § 102(b) be withdrawn.

Claim 20 as amended recites, *inter alia*:

"...l) *at any time relative to performing any of steps a) – g)*, periodically unmarking any marked card that does not contain at least one of said marked objects...wherein any of steps a) – g) are performed upon said population of objects concurrently with the operation of a mutator" (emphasis added).

Page 19 of the office action asserts that this feature is anticipated by Printezis at Fig. 1 and page 5, "A Concrete Example."

Applicants respectfully submit that Printezis does not anticipate the recited feature. Printezis unmarks cards and retraces all marked objects in them, *but only after the*

initial tracing is done. In contrast to Printezis, *the recited feature teaches that marked cards may be unmarked at any time*, even during concurrent GC and mutator operation, provided that the marked card contains no marked objects. Printezis therefore does not anticipate claim 20 under 35 U.S.C. § 102(b). Applicants respectfully request, therefore, that the rejection of claim 20 under 35 U.S.C. § 102(b) be withdrawn.

Claims and 21 – 23 depend directly or indirectly from independent claim 20, and are, *a fortiori*, deemed allowable. Applicants respectfully request, therefore, that the rejection of claims 21 – 23 under 35 U.S.C. § 102(b) be withdrawn.

Claims 31 – 37 are cancelled herewith without prejudice or disclaimer.

Claim 42 sets forth the invention in claim 12 as a system, and is deemed allowable in view of the discussion above with regard to claim 12.

Claim 43 sets forth the invention in claim 16 as a system, and is deemed allowable in view of the discussion above with regard to claim 16.

Claim 44 sets forth the invention in claim 20 as a system, and is deemed allowable in view of the discussion above with regard to claim 20.

Claim 46 has been amended to restate claim 12 in "Beauregard" format, and is deemed allowable in view of the discussion above with regard to claim 12.

Applicants respectfully request, therefore, that the rejection of claims 42 – 44 and 46 under 35 U.S.C. § 102(b) be withdrawn.

35 U.S.C. § 103(a) Rejections

Claims 8 - 11, 24, 28 – 30, 38 – 41, and 45 have been rejected under 35 U.S.C. §103(a), as being unpatentable over Printezis, et al. (hereinafter "Printezis"). in view of Barabash, et al. (hereinafter "Barabash"). Applicants respectfully traverse this rejection in view of the remarks that follow.

The Applicants, being also the authors of Barabash, respectfully point out that Barabash was not published in the ACM Transactions on Programming Languages, Vol. 8, No. 1, in January, 1999, as indicated in the page 1 footnote of Barabash. Rather, Barabash was formatted with a pro-forma footnote which indicated the Vol. 8, No. 1 bibliography, as well as unspecified pages "1-??". A draft copy of Barabash including the pro-forma

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language was published after the filing date of the instant application. Barabash was actually published in Vol. 27, No. 6, November, 2005, the first page of which is included herewith. The Table of Contents of ACM Transactions on Programming Languages, Vol. 8, No. 1, is also included herewith, showing that Barabash was not included in that issue.

Applicants respectfully requests, therefore, that the rejection of claims 8 – 11, 24, 28 – 30, 38 – 41, and 45 under 35 U.S.C. §103(a) be withdrawn. If the included showing is insufficient, Applicants request the Examiner's assistance in determining what additional showings are required to prove the true publication date of Barabash.

Conclusion

Applicant respectfully submits that consideration of the above remarks renders the present application in condition for allowance, which action Applicant respectfully solicits.

Petition For One-Month Extension Of Time Under 37 CFR 1.136(a)

The period for responding to the instant Notice was set to expire on April 25, 2006. Applicant hereby requests that the period for responding to the instant Office Action be extended by one (1) month, so as to expire on May 25, 2006. Accordingly, this response is being timely filed.

The fee for a Petition for a One-Month Extension of Time is One Hundred and Twenty Dollars ($120.00) dollars for a large entity. The United States Patent and Trademark Office is hereby authorized to charge Deposit Account 09-0468 in the amount of $120 and any additional fee which is necessary in connection with the filing of this response and petition.

Favorable action on this response is courteously solicited.

Respectfully submitted,

Date: May 12, 2006

By: _____

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A Parallel, Incremental, Mostly Concurrent Garbage Collector for Servers

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Multithreaded applications with multi-gigabyte heaps running on modern servers provide new challenges for garbage collection (GC). The challenges for "server-oriented" GC include: ensuring short pause times on a multi-gigabyte heap while minimizing throughput penalty, good scaling on multiprocessor hardware, and keeping the number of expensive multi-cycle fence instructions required by weak ordering to a minimum.

We designed and implemented a collector facing these demands building on the mostly concurrent garbage collector proposed by Boehm et al. Our collector incorporates new ideas into the original collector. We make it parallel and incremental; we employ concurrent low-priority background GC threads to take advantage of processor idle time; we propose novel algorithmic improvements to the basic mostly concurrent algorithm improving its efficiency and shortening its pause times; and finally, we use advanced techniques, such as a low-overhead work packet mechanism to enable full parallelism among the incremental and concurrent collecting threads and ensure load balancing.

We compared the new collector to the mature, well-optimized, parallel, stop-the-world mark-sweep collector already in the IBM JVM. When allowed to run aggressively, using 72% of the CPU utilization during a short concurrent phase, our collector prototype reduces the maximum pause time from 161ms to 46ms while only losing 11.5% throughput when running the SPECjbb2000 benchmark on a 600 MB heap on an 8-way PowerPC 1.1 GHz processors. When the collector is limited to a non-intrusive operation using only 29% of the CPU utilization, the maximum pause time obtained is 79ms and the loss in throughput is 15.4%.

Categories and Subject Descriptors: D.3.4 [Programming Languages]: Processors—*Memory management (garbage collection)*

General Terms: Languages, Performance, Algorithms

Additional Key Words and Phrases: Garbage collection, JVM, concurrent garbage collection.

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Preliminary versions of this work have appeared in [Ossia et al. 2002] and [Barabash et al. 2003].

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